CLAIMS

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An apparatus for illuminating a tooth so that optical characteristics of points on the tooth may be measured, comprising:

a light source for projecting light;

means for transmitting the light to create a region of constant irradiance;

means for disposing the points of the object to be measured a selected distance from the lens so that the points are illuminated in said region of constant irradiance.

2. The apparatus of claim 1 wherein said transmitting means is an achromatic doublet lens.

3. The apparatus of claim 1 wherein said light source, transmitting means and disposing means are incorporated into an illumination assembly used in conjunction with a device for measuring the color of teeth.

4. The apparatus of claim 3 comprising:

an image sensor;

means for transmitting a portion of the light reflected from the tooth to said image sensor;

means for positioning said plurality of transmitting means adjacent said image sensor whereby the image sensor collects a plurality of frames, each frame associated with a selected bandwidth of the light; and

means for combining said plurality of frames to create an image of the object.

5. The apparatus of claim 4 comprising means to display said image in a line of view whereby an operator of the apparatus can view said image from a same perspective as that which the image sensor collects said bandwidth.

6. The apparatus of claim 5 wherein said disposing means is a sanitary shield of a predetermined length for displacement adjacent or against a tooth.

7. The apparatus of claim 1 further comprising means to homogenize the light.

8. The apparatus of claim 7 wherein said homogenizing means is a light-shaping diffuser.

9. A device for measuring the optical characteristics of an object comprising:

means for illuminating the object with a searchlight illumination source;

means for collecting color information reflected from said object; and

means for processing the collected color information to produce an image of the object including the optical characteristics of the object.

10. The apparatus of claim 9 comprising means to display said image.

11. The apparatus of claim 10 comprising means for positioning the object a pre-selected distance from said searchlight illumination source.

12. The apparatus of claim 11 wherein said positioning means is a sanitary shield of predetermined dimensions.

13. The apparatus of claim 12 wherein said image is displayed on a display, said display in line of view whereby an operator of the apparatus can view the image from a same perspective as that which the image sensor collects the light.

14. An instrument for acquiring an image of a tooth located within a field of view, said instrument comprising:

a [redacted]held housing defining an aperture for [redacted]eiving light reflected from the tooth;

image sensor means within said housing and aligned with said aperture for acquiring an image of the tooth; and

illumination means for illuminating the field of view with light that is substantially uniform in three dimensions.

15. An instrument as defined in claim 14 wherein the light varies less than plus or minus 2 percent in any of the three dimensions.

16. An instrument as defined in claim 15 wherein the light varies less than plus or minus 1 percent in any of the three dimensions.

17. A method for illuminating an object to measure optical characteristics of that object chosen from color, shade, translucence, gloss, and shape comprising the steps of:

providing illumination;

creating a region of constant irradiance with the illumination;

disposing the object to be measured in the region of constant irradiance.

18. The method of claim 17 wherein the illumination is transmitted through a lens to create the region of uniform irradiance.

19. The method of claim 18 wherein the disposing step is carried out using a sanitary shield of a pre-selected length so that when the sanitary shield is positioned adjacent to or against the object, the object is in the region of constant irradiance.

20. A method for measuring the optical characteristics of an object comprising the steps of:

illuminating the object with searchlight illumination so that light is reflected from the object;

transmitting a plurality of time separated bandwidths of the reflected light;

collecting the time separated bandwidths; and

combining the time separated bandwidths into a single image including a plurality of points, each of the points having data representative of each of the time separated bandwidths.

21. The method of claim 20 comprising the step of disposing the entire object in a region at constant irradiance of the searchlight illumination.

22. The method of claim 21 wherein the disposing step is carried out using a sanitary shield of a pre-selected length so that when the sanitary shield is positioned adjacent to or against the object, the object is in the region of constant irradiance.

23. An apparatus for creating an image of an object comprising:

means for illuminating the object with illumination rays so that the object reflects reflected rays;

a monochromatic image sensor;

means for transmitting selected bandwidths included in one chosen from the illumination rays and the reflected rays;

means for disposing said transmitting means adjacent one chosen from said illuminating means and said image sensor whereby the image sensor collects a plurality of time separated frames, each frame associated with one of the bandwidths; and

means for combining said plurality of frames to create an image of the object.

24. The apparatus of claim 23 comprising means for aligning a plurality of points on a first frame with a plurality of points on at least a second frame to form a plurality of aligned points.

25. The apparatus of claim 24 wherein said image includes said plurality of aligned points, each of said aligned points including the selected bandwidths transmitted by said transmitting means.

26. The apparatus of claim 25 wherein said bandwidths include bandwidths chosen from X, Y, Z and X' tristimulus value bandwidths.

27. The apparatus of claim 26 comprising means for displaying the image in a line of view wherein an operator of the apparatus can view the image from the same perspective that the image sensor collects said plurality of time separated frames.

28. The apparatus of claim 23 wherein said transmitting means is a filter assembly including a plurality of filters chosen from X tristimulus bandwidth transmitting filters, Y tristimulus bandwidth transmitting filters, Z tristimulus bandwidth transmitting filters, and X' tristimulus bandwidth transmitting filters.

29. The apparatus of claim 28 wherein said filter assembly rotationally translates through a plurality of pre-selected angles to sequentially align each of said plurality of filters adjacent one from said illumination means and said image sensor.

30. The apparatus of claim 29 comprising means to prevent infrared bandwidths from impinging on said image sensor.

31. The apparatus of claim 30 comprising a position sensor to align the filter assembly adjacent one chosen from the illuminating means and the image sensor.

32. The apparatus of claim 31 wherein each of said plurality of aligned points corresponds to a point on the tooth.

33. The apparatus of claim 32 comprising means for displaying the image of the object.

34. The apparatus of claim 33 wherein said display means displays the image in a line of view of an operator of the apparatus whereby the operator can view the image from a same perspective as that which said image sensor collects plurality of frames.

35. The apparatus of claim 23 comprising wireless means for transmitting or receiving information chosen from image-related data and patient-related data.

36. An apparatus for measuring the optical characteristics of an object illuminated with incident light and reflecting reflected light from the object comprising:

means for transmitting separated bandwidths of light chosen from incident light and the reflected light;

an image sensor for collecting said separated bandwidths of the reflected light; and

a processor to combine and align said separated bandwidths into a single image representative of the optical characteristics of the object.

37. The apparatus of claim 36 wherein said image sensor is a monochromatic sensor chosen from a CCD or a CMOS.

38. The apparatus of claim 37 wherein said transmitting means is a translatable tristimulus filter that transmits a plurality of single tristimulus value bandwidths during a corresponding plurality of discrete time increments.

39. The apparatus of claim 38 comprising means to synchronize the translation of said tristimulus filter and the collection of said separated bandwidths by said image sensor.

40. The apparatus of claim 39 comprising means to display the image in a line of view of an operator of the apparatus whereby the operator can view the image from a same perspective as that which the image sensor collects said bandwidths.

41. The apparatus of claim 37 comprising wireless means to download information related to said image to at least one chosen from a docking station and a computing device.

42. The apparatus of claim 37 comprising wireless means to upload information related to at least one chosen from a docking station and a computing device.

43. An instrument for acquiring a color image of a tooth comprising:

a handheld housing;

a light source within said housing providing illumination of the tooth;

an image sensor within said housing for acquiring an image of the tooth; and

filter means within said housing for selectively filtering the image of the tooth, said filter means including a plurality of filters at different bandwidths, said filter means further including means for moving said filters sequentially in alignment with said image sensor so that said image sensor acquires time-separated images of the tooth at different filtered bandwidths; and

processor means for combining the time-separated images into a single color image.

44. An instrument as defined in claim 43 wherein said filters are tristimulus filters.

45. A method for determining the optical characteristics of an object comprising the steps of:

illuminating the object with incident light reflected so that light is reflected from the object;

transmitting pre-selected time-separated bandwidths included in light chosen from the incident light and the reflected light;

sensing the pre-selected time-separated bandwidths in a plurality of frames, each frame associated with a single bandwidth and time separated;

aligning the plurality of frames; and

combining the plurality of frames to create an image of the object including optical characteristic data.

46. The method of claim 45 wherein said aligning step includes aligning a plurality of points on a first frame with a plurality of points on at least a second frame to form a plurality of aligned points.

47. The method of claim 46 wherein the image includes the plurality of aligned points, each of the aligned points including the bandwidths transmitted by said transmitting means.

48. The method of claim 45 wherein said bandwidths include bandwidths chosen from X, Y, Z and X' tristimulus bandwidths.

49. The method of claim 45 comprising the step of displaying the image in a line of view of an operator of the apparatus whereby the operator can view the image from a same perspective as that from which the bandwidths are sensed during said sensing step.

50. The method of claim 45 wherein said transmitting step is carried out with a filter assembly including a plurality of filters chosen from X tristimulus bandwidth transmitting filters, Y tristimulus bandwidth transmitting filters, Z tristimulus bandwidth transmitting filters, and X' tristimulus bandwidth transmitting filters.

51. The method of claim 50 comprising the step of translating the filter assembly through a plurality of pre-selected angles to sequentially align each of the plurality of filters so that the bandwidths may be sensed.

52. The method of claim 45 comprising the step of blocking infrared light whereby the infrared light is not sensed during said sensing step.

53. A method for creating an image of an illuminated object comprising the steps of:

transmitting a plurality of time separated bandwidths of light that illuminates the object;

collecting the time separated bandwidths; and

combining the time separated bandwidths into a single image including a plurality of points, each of the points having data representative of each of the time separated bandwidths.

54. The method of claim 53 wherein said transmitting step is carried out by disposing a filter that transmits a pre-selected bandwidth between the object and a source of illumination whereby light from the illumination source is transmitted in a plurality of time separated bandwidths to said object and said object reflects said time separated bandwidths.

55. The method of claim 53 wherein said transmitting step is carried out by disposing a filter that transmits a pre-selected bandwidth between the object and a sensor that carries out said collecting step whereby light reflected from the illuminated object is transmitted in a plurality of time separated bandwidths to the sensor.

56. The method of claim 54 comprising the step of displaying the image in a line of view whereby an operator of the apparatus can view the image from a same perspective as the time separated bandwidths are collected.

57. The method of claim 55 comprising the step of displaying the image in a line of view whereby an operator of the apparatus can view the image from a same perspective as the time separated bandwidths are collected.

58. The method of claim 54 wherein the time separated bandwidths are chosen from X, Y, Z and X' tristimulus bandwidths.

59. The method of claim 55 wherein the time separated bandwidths are chosen from X, Y, Z and X' tristimulus bandwidths.

60. The method of claim 54 wherein the filter includes a plurality of filters chosen from X tristimulus bandwidth transmitting filters, Y tristimulus bandwidth transmitting filters, Z tristimulus bandwidth transmitting filters, and X' tristimulus bandwidth transmitting filters.

61. The method of claim 55 wherein the filter includes a plurality of filters chosen from X tristimulus bandwidth transmitting filters, Y tristimulus bandwidth transmitting filters, Z tristimulus bandwidth transmitting filters, and X' tristimulus bandwidth transmitting filters.

62. The method of claim 60 wherein said collecting step is carried out with a monochromatic image sensor.

63. The method of claim 61 wherein said collecting step is carried out with a monochromatic image sensor.

64. The method of claim 53 comprising the step of downloading with wireless communication information chosen from the image, information related to the image and patient information to a computing device.

65. The method of claim 53 comprising the step of uploading with wireless communication information chosen from the image, information related to the image and patient information to a computing device.

66. A shield for a device for measuring optical characteristics of an object having an illumination source comprising:

a body including a first end and a second end distal from said first end, said first end defining an aperture, said body establishing a predetermined distance between the illumination source and the object when said aperture is placed in a position chosen from the object and adjacent object;

means for engaging said second end against the measuring device whereby ambient light is restricted from entering said body portion; and

a reference color disposed proximate said first end.

67. The shield of claim 66 wherein said reference color is disposed adjacent said aperture.

68. The shield of claim 67 wherein said second end in illuminatory communication with the illumination source.

69. The shield of claim 68 including means to indicates at least one chosen from the origin of the shield, lot number of the shield, expiration date of the shield and patient information, said indicating means disposed proximate said aperture whereby said indicating means are included in any measurement collected by the color measuring device.

70. The shield of claim 69 including means for restricting ambient light from entering said body through said aperture.

71. The shield of claim 70 wherein said restricting means circumferentiates said aperture.

72. The shield of claim 69 wherein said body is disposable.

73. The shield of claim 69 wherein said body is reusable.

74. A shield for a color measuring device used in dental applications comprising:

a body defining a cavity and including first and second end in illuminatory communication with one another, said first end separated from said second end a pre-selected distance;

a first aperture defined by said first end, said aperture for disposing in a position chosen from against and adjacent an object to be color measured;

a second aperture defined by said second end for disposing proximate an illumination source; and

a reference color associated with said body proximate said first aperture whereby said reference color is measured by the color-measuring device during color measurements.

75. The shield of claim 74 wherein the shield is used to prevent contamination from passing from a first patient to subsequent patients.

76. The shield of claim 75 comprising means for releasably attaching said body to the color-measuring device.

77. The shield of claim 76 wherein the reference color is used to establish an illuminant compensation factor when the color measuring device measures color.

78. The shield of claim 77 comprising indicia that is included in any measurement taken by the color measurement device.

79. The shield of claim 78 wherein said indicia at least one chosen from the origin of the shield, lot number of the shield, expiration date of the shield and patient information.

80. A shield for a device used to measure the color of dental objects comprising:

a member defining a cavity through which illumination may pass, said member of a predetermined length to establish a selected distance between a measured dental object and a source of illumination; and

a reference color associated with said member.

81. The shield of claim 80 comprising means for releasably securing said member to the color measuring device.

82. The shield of claim 81 wherein the member is disposable.

83. The shield of claim 82 wherein the member is opaque to prevent ambient light from entering said cavity.

84. The shield of claim 83 wherein the reference color is used to establish a compensation factor when the color measuring device measures color.

85. The shield of claim 84 comprising means to indicate the origin of the shield, said indicating means positioned so that it is measured when the color measuring device measures color.

86. An instrument for acquiring a color image of a tooth within a field of view, said instrument comprising:

a handheld housing;

an illumination source within said housing for illuminating the field of view;

an image sensing device within said housing for sensing an image of the tooth; and

a disposable shield including a first end removably connected to said housing and a second end defining an aperture within the field of view, the shield providing a desired spacing between the tooth and the image sensing device when the second end is placed against a portion of a patient's mouth, at least a portion of the second end also being within the field of view, said portion being of a desired uniform color so that said portion provides a reference color within the field of view to said image sensing device.

87. An instrument as defined in claim 86 wherein said first end provides a light-tight seal against said housing.

88. A device for measuring tooth shade or color comprising:

a sensor for collecting data chosen from color data and shade data of a tooth, said sensor having a line of sensing in which an object must be disposed to collect said data; and

means for displaying the data in the form of an image of the tooth, said display means including a line of viewing by which a user of the device may view the image on the display means, said line of viewing substantially aligned with said line of sensing whereby the user views the tooth from a perspective that is the same as the perspective that said sensor senses the tooth.

89. The device for measuring tooth color or shade of claim 88 wherein said display means is substantially aligned behind said image sensor.

90. device for measuring tooth color or shade of claim 89 wherein the image sensor and display means are included in a cordless, handheld unit.

91. The device for measuring tooth color or shade of claim 90 wherein said image sensor is a monochromatic image sensor.

92. The device for measuring tooth color or shade of claim 91 comprising a filter that sequentially transmits the separated tristimulus bandwidths to said image sensor.

93. The device for measuring tooth color or shade of claim 92 comprising a shield releasably secured to the optical characteristic measuring device, said shield for placement against or adjacent the measured tooth to prevent contamination of the device.

94. The device for measuring tooth color or shade of claim 93 wherein said shield separates the sensor from the tooth measured by a pre-selected distance.

95. A handheld device for measuring optical characteristics chosen from color, translucence and gloss of a dental object comprising:

means for collecting optical characteristics from a first perspective;

means for displaying an image of the collected optical characteristics in a second perspective, said second perspective identical to said first perspective and wherein said first perspective is immediately behind said second perspective in a line of view of an operator using the handheld device.

96. The handheld device of claim 95 wherein the operator can perceive the second perspective when the collecting means collects the optical characteristics.

97. The handheld device of claim 96 wherein the operator can manipulate the handheld device to select the first perspective that the operator perceives the display means.

98. The handheld device of claim 97 wherein the collecting means is separated a pre-selected distance from the object measured.

99. The handheld device of claim 98 comprising a disposable sanitary shield disposed adjacent said collecting means to establish said pre-selected distance.

100. A system for collecting optical characteristic measurements of an object comprising:

a sensor that collects an image of an object in a first field of view; and

means for displaying the image in a second field of view, said first and second fields of view aligned one behind the other so that a user of the system perceives the image on the display means from the same field of view as the sensor collects the image.

101. The system of claim 100 wherein said sensing means and said display means are incorporated into a portable, handheld unit.

102. The system of claim 101 comprising a sanitary shield releasably attached to said unit.

103. The system of claim 102 wherein said sanitary shield is of a length to separate the object from the image sensor a pre-selected distance.

104. The system of claim 103 comprising means to transmit only tristimulus value bandwidths of the image to said image sensor.

105. The system of claim 104 wherein said display means is a LCD.

106. An instrument for acquiring a color image of a tooth comprising:

a handheld housing;

an image sensing device within said housing for sensing light reflected in a first direction; and

a dynamic image display device within said housing for displaying an image of the tooth as sensed by said image sensing device, said image display device being generally perpendicular to the first direction and generally aligned with the first direction.

107. An instrument for acquiring a color image of a tooth comprising:

a handheld housing defining a sensing aperture and a display aperture;

at least one of a communication connection and a power connection within said housing and accessible from outside said housing;

a window sealed within said sensing aperture;

a display sealed within said display aperture; and

said instrument being substantially moisture-proof with the possible exception of said at least one connection, whereby said instrument with the possible exception of said at least one connection can be wiped down for sanitation purposes without moisture entering said housing.

108. A system for measuring the optical characteristics of teeth comprising:

a housing defining an aperture and including a portal;

means for illuminating a tooth through said aperture disposed in said housing;

means for sensing an image of the tooth through said aperture disposed in said housing; and

means for sealably covering said aperture whereby pollutants are prevented from entering said housing, except for the possible entrance of pollutants through said portal.

109. The system of claim 108 wherein said covering means is transparent.

110. The system of claim 109 wherein said covering means is a panel made from a material chosen from glass, plastic, and synthetic materials.

111. The system of claim 110 wherein said panel is secured to said housing with a gasket disposed between said panel and said housing.

112. A housing for an intraoral optical measurement device comprising:

a body defining an interior for containing optical sensor, said body further defining a measurement aperture and a connection aperture;

a transparent window disposed over said aperture so that optical measurements can be taken through said window;

a seal disposed between said housing and said window so that body prevents pollutants from entering said interior, with the exception of pollutants possibly entering said interior through said connection aperture, when the body is wiped down for purposes chosen from cleaning purposes and sanitizing purposes; and

a display window sealably mounted in said body.

113. The housing of claim 112 comprising a display window sealed.

114. The housing of claim 112 wherein said display window is touch sensitive to allow operation of the measurement device.

115. The housing of claim 112 wherein said seal is in the form of a gasket that circumferentiates a boundary of said window.

116. The housing of claim 112 wherein said seal is in the form of a sealing adhesive that circumferentiates an exterior boundary of said window.

117. A method for creating dental prosthesis comprising the steps of:

measuring the optical characteristics of a tooth;

creating tooth data from the measured tooth optical characteristics;

manufacturing a dental prosthesis from the tooth data;

measuring the optical characteristics of the dental prosthesis;

creating prosthesis data from the measured prosthesis optical characteristics; and

comparing the prosthesis data to the tooth data to insure the data match.

118. The process of claim 117 comprising the step of forwarding the tooth data from a first person who measured the tooth data to a second person who aids in said manufacturing step.

119. The process of claim 118 comprising the step of forwarding the dental prosthesis data from the second person back to the first person.

120. The process of claim 119 comprising the step of altering the dental prosthesis if the prosthesis data does not match the tooth data.

121. The process of claim 120 wherein the tooth optical characteristics and the prosthesis optical characteristics are characteristics chosen from color, translucence, and gloss.

122. A process for matching the optical characteristics of objects chosen from a tooth and its surrounding teeth with a prosthetic replacement for a tooth comprising the steps of:

collecting first data for objects chosen from a tooth and surrounding teeth;

creating a dental prosthesis from the first object data to replace the tooth;

collecting second prosthesis data from the dental prosthesis; and

comparing the first data to the second prosthesis data to insure the dental prosthesis accurately duplicates the tooth for which it was created to replace.

123. The process of claim 122 wherein a dentist collects the first data and carries out said comparing step.

124. The process of claim 123 wherein a tooth manufacturer carries out said collecting second prosthesis data step.

125. The process of claim 124 comprising the step of manufacturing a second dental prosthesis if said comparing step indicates that the dental prosthesis does not accurately duplicate the tooth for which it was created to replace.

126. The process of claim 125 comprising the step of collecting third prosthesis data from the second dental prosthesis.

127. The process of claim 126 comprising the step of comparing the first data with the third prosthesis data to insure the second dental prosthesis accurately duplicates the tooth for which it was created to replace.

128. A process for creating a dental prosthesis comprising the steps of:

creating tooth data from an image of a tooth;

manufacturing a prosthesis from the tooth color data;

creating prosthesis data from an image of the prosthesis;

comparing the tooth data to the prosthesis color data; and

taking corrective action if the tooth color data and the prosthesis color data do not match, wherein the corrective action is chosen from altering the prosthesis and creating a substitute prosthesis.

129. The process of claim 128 wherein a dentist performs said comparing step.

130. The process of claim 129 wherein the dentist instructs a second party to conduct said corrective action step.

131. A method of displaying information regarding a dental prosthesis comprising:

creating a color image of a tooth at a first location;

sending the tooth color image to a second location;

making a prosthesis at the second location having a desired visual relationship with respect to the tooth color image;

creating a color image of the prosthesis at the second location;

sending the prosthesis color image to the first location; and

simultaneously displaying at the first location the tooth color image and the prosthesis color image for evaluation of the actual visual relationship between the tooth color image and the prosthesis color image.

132. A [redacted]thod as described in claim 131 wherein [redacted]d tooth and prosthesis color images are digital images.